Volume 9, No. 3, March - 2018 (Special Issue)
International Journal of Mathematical Archive-9(3), 2018, 133-139
IJMA Available online through www.ijma.info ISSN 2229 – 5046

A CASE STUDY IN ROOF GARDEN

J. TAMILMANI
Department of Mathematics,
Sri Sarada College for Women Autonomous, Salem – 16, Tamil Nadu, India.
E-mail: tamilmani.jambu@gmail.com

ABSTRACT

As the world is heading towards the drain out of natural resources and the loss of forest/ agricultural area due to urbanization, there is a need of roof gardens. Due to the population explosion, all the open areas are occupied by concrete buildings. When we cannot avoid utilizing open spaces on the ground for the construction of buildings and other utilities, then at least the open spaces available above these buildings can be utilized for plantations and gardens. It is very suffices to use roofs of the building for gardens. In this paper we discussed the need of roof gardens, and how to minimize the cost of making roof gardens by using linear programming problem.

Keywords: *Linear programming problem, Fuzzy linear programming problem, Yager Ranking function.*

2010 AMS Classification: *03E72.*

1. INTRODUCTION

Operation research was first coined in 1940 by McClosky and Tref then in a small town, Bowdsey of the U.K. Operations Research (OR) is an analytical method of problem solving and decision making that is useful in the management of organizations. Today, almost every large organization or corporation in affluent nations has staff applying operations Research. Since Linear programming is probably the most widely used mathematical optimization technique, numerous computer programs are available for solving LP problems. Fuzzy set theory has become an important tool in the branch of decision sciences and has been applied successfully to many disciplines such as control theory, management sciences, mathematical modeling and industrial applications. The concept of fuzzy set was introduced by Zadeh in his classical paper [9]. The concept of fuzzy decision was introduced by Bellman and Zadeh [2], later Tanaka Okuda and Asai [7] first extended the concept as fuzzy linear programming (FLP) problems on general level. A number of researchers have exhibited their interest to solve the FLP problems and proposed several approaches for solving these problems. Ganesan and Veeramani [5], after Zimmermann [10] proposed the formulation of FLP.

Dr. Padmashri R.T. Doshi [4] has developed a system for urban roof and balcony and roof gardens in India that makes use of cheap, readily available local materials. Dr.Doshidescribes his system in detail in a 2003 article of "Urban Agriculture Magazine." His innovations are efforts to reduce the costs and labor of farming. With the congestion of city life, a vegetable garden for apartment dwellers seems to be a difficult prospect. However the concept of Organic Terrace Garden is gaining ground everywhere, as more apartment dwellers want their own home-grown vegetables. With proper research, we can grow fresh vegetables in our high-rise building.

In this article we discussed the overview of roof garden benefits and challenges. And we examined the factors by which people think roof gardening is inevitable thing and find the minimum optimal solution for making roof garden by using fuzzy linear programming problem.

2. PRELIMINARIES

Linear programming deals with the optimization (maximization or minimization) of a function of variables known as objective function, subject to a set of linear equations and/or inequality known as restrictions or constraints. Fuzzy linear programming deals with the optimization (maximization or minimization) of a function of variables known as fuzzy objective function, subject to a set of fuzzy linear equations and/or inequality known as restrictions or fuzzy constraints.

CONFERENCE PAPER
National Conference dated 26th Feb. 2018, on "New Trends in Mathematical Modelling" (NTMM - 2018), Organized by Sri Sarada College for Women, Salem, Tamil Nadu, India.

Definition 2.1[3]: The characteristic function μ_A of a crisp set $A \subset X$ assigns a value either 0 or 1 to each member in X. This function can be generalized to a function $\mu_{\tilde{A}}$ such that the value assigned to the element of the universal set X fall within a specified range i.e. $\mu_{\tilde{A}}: X \to [0,1]$. The assigned value indicate the membership function and the set $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)); x \in X\}$ is defined by $\mu_{\tilde{A}}(x)$ for $x \in X$ is called fuzzy set.

Definition 2.2[1]: The support of a fuzzy set $\tilde{A}$ is the crisp set of points $x \in X$ such that $\mu_{\tilde{A}}(x) \geq 0$.

Ranking function [6]: An efficient approach for ordering the elements is to define a ranking function $\mathcal{R}: F(\mathcal{R}) \to \mathcal{R}$ which maps for each fuzzy number into the real line, where a natural order exists. We define orders as follows

$\tilde{A} \geq \tilde{B} \Leftrightarrow \mathcal{R}(\tilde{A}) \geq \mathcal{R}(\tilde{B})$

$\tilde{A} \leq \tilde{B} \Leftrightarrow \mathcal{R}(\tilde{A}) \leq \mathcal{R}(\tilde{B})$

$\tilde{A} = \tilde{B} \Leftrightarrow \mathcal{R}(\tilde{A}) = \mathcal{R}(\tilde{B})$

Where $\tilde{A}, \tilde{B}$ are in $F(\mathcal{R})$.

We restrict our attention to linear ranking function. i.e, a ranking function $\mathcal{R}$ such that,

$$\mathcal{R}(K\tilde{A} + \tilde{B}) = K\mathcal{R}(\tilde{A}) + \mathcal{R}(\tilde{B}) \ \forall \ \tilde{A}, \tilde{B} \in F(\mathcal{R}).$$

Yager ranking function [8]

Let $\tilde{A} = (a^l, a^u, \alpha, \beta)$ be a trapezoidal fuzzy number, then the ranking function is

$$\mathcal{R}(\tilde{A}) = {}^1\!/_2 \left(\int_0^1 (\inf \tilde{a}_\lambda + sup\tilde{a}_\lambda) d\lambda\right)$$

$$\mathcal{R}(\tilde{A}) = {}^1\!/_2 \left(a^l + a^u + {}^1\!/_2 (\beta - \alpha)\right)$$

Where $\alpha = \beta \ or \ \alpha \neq \beta$.

General form of fuzzy LPP [3]

The fuzzy linear programming problem (fuzzy LP problem) has a general form as follows:

Max $\tilde{C}\tilde{X}$

Subject to: $A\tilde{X} \leq \tilde{B}$,

$\tilde{X} \geq 0$

Where $\tilde{B} \ \ and \ \tilde{X}$ are fuzzy variables, $A \in R^{m \times n}$ and $\tilde{C}^T \in (F(R))^n$.

We will develop the crisp simplex method into fuzzy simplex method. We propose the fuzzy simplex method which is based on the arithmetic operation of the trapezoidal fuzzy numbers, the properties of ranking functions and the classic simplex method.

ALGORITHM

Step-1: Formulate the chosen problem into the following fuzzy linear programming problem

Max (or) min$\tilde{z} = \tilde{c_j}\tilde{x_j}$

Subject to $A_{ij}\tilde{x_j} \leq \tilde{B_i}$,

$\tilde{x_j} \geq 0$

Step-2: Using the ranking function,

$$R(\tilde{A}) = \frac{1}{2}\left(a^l + a^u + \frac{1}{2}(\beta - \alpha)\right)$$

The FVLPP is transformed into the following form:

Max (or) min$\tilde{z} = c_j\tilde{x_j}$

Subject to: $A_{ij}\tilde{x_j} \ \leq \ \tilde{B_i}$,

$\tilde{x_j} \geq 0$

Step-3: Solve the FVLPP by using simplex method/big-M method. Then we get the solution of FVLPP is $\tilde{x_j}$.

Step-4: Express the problem in standard form by introducing slack/surplus variables, to convert the inequality constraints into equations.

Step-5: Compute the value of $\tilde{Z} = C_B Y_j - C_j \ \ j \neq B, \ j = 1,2, \ldots \ldots n$.

(i) If all $\tilde{Z} \geq 0$, $\forall j$ for maximization problem.

(ii) If all $\tilde{Z} < 0$, $\forall j$ for minimization problem. Then the current solution is optimal, otherwise go to Step 6:

Step-6: Determine the basic variable $\tilde{x}_k$, which will be replaced by the non-basic variable, where $k =$ arg min $\{\mathcal{R}(\tilde{\tilde{B_i}})\} i = 1,2, \ldots . . m$, in maximization problem and $k =$ arg max $\{\mathcal{R}(\tilde{\tilde{B_i}})\} i = 1,2, \ldots . . m$, in minimization problem.

Step-7: Perform the pivot operation and return to step 5. Then repeat the procedure until a fuzzy optimal solution is obtained.

Overview of Roof Garden Benefits and Challenges

Why it may be difficult to make a roof garden?

It may be that we haven't been able to make a roof garden. There are several reasons why it may be difficult to make a kitchen garden, or if we have made one, it is not successful. For examplepests, diseases have destroyed the crop, no good seed or seedling, lack of space, lack of water, lack of fertility, no spare time, lack of the right skills.

Benefits of the Roof Garden

We can grow healthy, fresh vegetables, we can save the cost of buying vegetables and herbs, waste resources such as sweepings, kitchen scraps anddirty water can be recycled onto the garden. Rooftops plantings can reduce the money spent on heating and cooling buildings,as well as improving urban air quality. Reduced energy usage also reduces greenhousegas emissions.

Things to pay attention to make roof gardening

To make and manage a kitchen garden easily, and to give best production, the following things are important: Seed & seedlings, Fertility, Water management, Protection.

Good management of the garden needs knowledge of all these. Then we can make our kitchen garden more successful.

Seed & seedlings

From good seed, it is importantto be able to raise good, healthy seedlings for transplanting into the kitchen garden.

Compost

This is a broken down, decomposed form of kitchen waste, dried leaves, cow dung, and more. The process of decomposition takes about 6-8 weeks. When this breaking down process is done with the help of a specific breed of earth worms (common name: Red Wiggler; scientific name: Eisenia fetida or Eisenia andrei), the end result is called vermicompost. This is one of the most important items that make our garden organic. On an average, compost costs approximately Rs. 4 to Rs. 25 a kilo. This is made from coconut husks and has absolutely no nutrition in it, but has excellent water retention capacity. It is added so that the container retains more moisture for the plants and it reduces the weight on your balcony/terrace.

Water Management

It is important to provide enough moisture for thekitchen garden. There are many ways of conserving and increasing the moisture available. For example

Green Manures: also cover the soil, and so help inconserving water;

Windbreak: wind will dryout the soil, so stopping thewind helps to conserve soilmoisture;

Protection

Then, the crops within the garden will also need protection from damage by many types of pest and disease. There are many ways to do this. Mixed cropping, rotations, liquid manure, etc. are all ways of protecting crops. Also we may use nets to cover the area of roof garden. The average cost of net is Rs. 350 per square meter.

Containers

We may use plant bags to grow the healthiest of plants at home. Choose from a variety of plant bags from top brands such as Coco garden, agricom, Seed stores and more. A multitude of plant bags and sacks in various dimensions can be used for plant cultivation. Plant bags allow water to drain freely and air to circulate to the roots of the plant. Therefore, they help in growing healthier plants. Plant bags also aid in reducing the heat build-up inside the pots and provide a favourable growth environment for your delicate plants. So, no matter what type of plants you want to grow, plant bags can help you to grow your favourite plants without much hassle. The average cost of bags is Rs. 300 per 10 bags of dimension 12” × 12”.

We can grow at least 6 vegetables per season. 1 sqm of terrace area can give anywhere between 25 to 50 kg of vegetables in a year.

Examine the Factor by which People Think Roof Gardening is Inevitable Thing

Study area

This work is based on the field work conducted at Alagapuram. It is in Salem Taluk and Salem district, Tamilnadu. We have visited some places via Sona Nagar, Mitta Pudur and MG Road at Alagapuram to collect the qualitative data about their issues. The data collected from 75 people using linguistic questionnaire and it issolved by using fuzzy LPP.

Survey Questionnaire on Roof Garden

1. Do you aware of roof garden/terrace garden?	Yes/No
2. Do you think in future roof garden play a vital role?	Yes/No/ Don't Know
3. Do you encourage your young generation to make roof garden?	Yes/No/ Don't Know
4. Do you think roof garden will save the cost of buying vegetables?	Yes/No/ Don't Know
5.Do you need any agricultural background to start a roof garden?	Yes/No
6. Can roots of plants cause any harm to the building?	Yes/No/ Don't Know
7. How much will a terrace garden cost?	Low/ High / Very high
8. How much time will it take to begin a terrace garden?	Days/ Weeks / Months
9. Will maintenances consume a lot of time?	Yes/No/ Don't Know
10. What is the average cost of vegetables consumed per day?	20-30/30-40/above 40

The table below shows the number of people who answered for the questions 2, 3 and 5.

Various issues / places		Sona Nagar	Mitta Pudur	MG Road	Total
In future roof gardenplay a vital role	Yes	15 a_{11}	18 a_{12}	21 a_{13}	54b_1
	No	5 a_{21}	3 a_{22}	4 a_{23}	12b_2
	Don't know	5 a_{31}	4 a_{32}	- a_{33}	9b_3
Encourage young generation to make roof garden	Yes	16 a_{41}	14 a_{42}	22 a_{43}	52b_4
	No	7 a_{51}	4 a_{52}	3 a_{53}	14b_5
	Don't know	2 a_{61}	7 a_{62}	- a_{63}	9b_6
Need agriculture background	Yes	7 a_{71}	9 a_{72}	5 a_{73}	21b_7
	No	13a_{81}	10 a_{82}	17 a_{83}	40b_8
	Don't know	5a_{91}	6 a_{92}	3 a_{93}	14b_9

Table-11

There are many benefits of these roof gardens, such as waste recycling, ecological benefits, energy conservation, water conservation, decorative enhancement of buildings, occupant's health benefits and attracting birds and insects. The list can be much longer.

The following table shows the number of people why they think roof garden plays an important role in future.

Sources/places	Sona Nagar	Mitta Pudur	MG Road	Total
	No.of people	No. of people	No. of people	
Fresh vegetables	12	8	9	29
Ecological imbalance	3	10	6	19
Save the cost of buying vegetables	10	7	10	27

Formulation of LPP

The general form of the constraint equation is

$$a_{11}\tilde{x}_1 + a_{12}\tilde{x}_2 + a_{13}\tilde{x}_3 \leq \tilde{B}_1$$
$$a_{41}\tilde{x}_1 + a_{42}\tilde{x}_2 + a_{43}\tilde{x}_3 \leq \tilde{B}_2$$
$$a_{71}\tilde{x}_1 + a_{72}\tilde{x}_2 + a_{73}\tilde{x}_3 \leq \tilde{B}_3$$
$$\tilde{x}_1, \tilde{x}_2, \tilde{x}_3 \geq 0$$

With the help of above data we have considered various aspects of roof gardening like in future roof garden play a vital role, Encourage young generation to make roof garden and Need agriculture background as parameters for our study. Decision variables

$\tilde{B}_1 = (b^{l_1}, b^{u_1}, \gamma_1, \theta_1)$ - Total No. of people in who answered for the Q. No. 2
b^{l_1} - No. of people who answered **Don't know**
b^{u_1} - No. of people who answered **Yes and Don't Know**
γ_1- No. of people who answered **Yes**
θ_1 - No. of people who answered **No**
$\tilde{B}_2 = (b^{l_2}, b^{u_2}, \gamma_2, \theta_2)$ – Total No. of people who answered for the Q. No. 3
b^{l_2}- No. of people who answered **Don't know**
b^{u_2} - No. of people who answered **Yes and Don't Know**
γ_2 - No. of people who answered **Yes**
θ_2 -No. of people who answered **No**
$\tilde{B}_3 = (b^{l_3}, b^{u_3}, \gamma_3, \theta_3)$ – Total No. of people who answered for the Q. No. 5
b^{l_3} - No. of people who answered **Don't know**
b^{u_3} - TotalNo. of people who answered **Yes and Don't Know**
γ_3 - TotalNo.of people who answered **Yes**
θ_3 - TotalNo.of people who answered **No**

From table1,

The constraint equation is of the form

$$15\tilde{x}_1 + 18\tilde{x}_2 + 21\tilde{x}_3 \leq (9,63,51,12)$$
$$16\tilde{x}_1 + 14\tilde{x}_2 + 22\tilde{x}_3 \leq (10,6154,14)$$
$$7\tilde{x}_1 + 9_2 + 5\tilde{x}_3 \leq (14,35,21,40)$$
$$\tilde{x}_1, \tilde{x}_2, \tilde{x}_3 \geq 0$$

Objective function
In general, the objective function can be written in the form

$$\text{Max } \tilde{Z} = \tilde{A}_1\tilde{x}_1 + \tilde{A}_2\tilde{x}_2 + \tilde{A}_3\tilde{x}_3$$

Where

$$\tilde{A}_1 = (a^{l_1}, a^{u_1}, \alpha_1, \beta_1),$$
$$\tilde{A}_2 = (a^{l_2}, a^{u_2}, \alpha_2, \beta_2),$$
$$\tilde{A}_3 = (a^{l_3}, a^{u_3}, \alpha_3, \beta_3)$$

From table 1, we have

$$a^{l_1} = \frac{a_{13} + a_{33} + a_{43} + a_{63} + a_{73} + a_{93}}{3} = 17$$
$$a^{u_1} = b_1 = 54$$
$$\alpha_1 = \frac{a_{12} + a_{32} + a_{42} + a_{62} + a_{72} + a_{92}}{3} = 16$$
$$\beta_1 = \frac{a_{11} + a_{31} + a_{41} + a_{61} + a_{71} + a_{91}}{3} = 13.33$$

Therefore $\tilde{A}_1 = (17,54,16,13.33)$ and

$$a^{l_2} = \frac{a_{13} + a_{43} + a_{73}}{3} = 16$$
$$a^{u_2} = \frac{b_1 + b_4 + b_7}{3} = 42.33$$
$$\alpha_2 = a_{12} + a_{42} + a_{72} = 41$$
$$\beta_2 = a_{11} + a_{41} + a_{71} = 38$$

Therefore, $\tilde{A}_2 = (16,42.33,41,38)$

$$a^{l_3} = a_{33} + a_{63} + a_{93} = 3$$
$$a^{u_3} = \frac{b_3 + b_6 + b_9}{3} = 10.67$$
$$\alpha_3 = \frac{a_{32} + a_{62} + a_{92}}{3} = 6.33$$
$$\beta_3 = a_{31} + a_{61} + a_{91} = 12$$

Therefore, $\tilde{A}_3 = (3,10.67,6.33,12)$

Then we have,

$$\text{Max } \tilde{Z} = (17,54,16,13.33)\tilde{x}_1 + (16,42.33,41,38)\tilde{x}_2 + (3,10.67,6.33,12)\tilde{x}_3$$

Then, the appropriate fuzzy LPP is

$$\text{Max } \tilde{Z} = (17,54,16,13.33)\tilde{x}_1 + (16,42.33,41,38)\tilde{x}_2 + (3,10.67,6.33,12)\tilde{x}_3$$

Subject to:
$15\tilde{x}_1 + 18\tilde{x}_2 + 21\tilde{x}_3 \leq (9,63,54,12)$
$16\tilde{x}_1 + 14\tilde{x}_2 + 22\tilde{x}_3 \leq (9,61,52,14)$
$7x_1 + 9x_2 + 5\tilde{x}_3 \leq (14,35,21,40)$
$\tilde{x}_1, \tilde{x}_2, \tilde{x}_3 \geq 0$

Solution: Standard form

By introducing slack variables $\tilde{x}_4, \tilde{x}_5, \tilde{x}_6 \geq 0$
Max $\tilde{Z} = (17,54,16,13.33)\tilde{x}_1 + (16,42.33,41,38)\tilde{x}_2 + (3,10.67,6.33,12)\tilde{x}_3 + (0,0,0,0)\tilde{x}_4 + (0,0,0,0)\tilde{x}_5 + (0,0,0,0)\tilde{x}_6$
Subject to
$15\tilde{x}_1 + 18\tilde{x}_2 + 21\tilde{x}_3 + \tilde{x}_4 + 0\tilde{x}_5 + 0\tilde{x}_6 = (9,63,54,12)$
$16\tilde{x}_1 + 14\tilde{x}_2 + 22\tilde{x}_3 + 0\tilde{x}_4 + \tilde{x}_5 + 0\tilde{x}_6 = (9,61,52,14)$
$7\tilde{x}_1 + 9x_2 + 5\tilde{x}_3 + 0\tilde{x}_4 + 0\tilde{x}_5 + \tilde{x}_6 = (14,35,21,40)$,
$\tilde{x}_1, \tilde{x}_2, \tilde{x}_3, \tilde{x}_4, \tilde{x}_5, \tilde{x}_6 \geq 0$

Using Yager ranking function

$$\mathcal{R}(\tilde{A}) = \frac{1}{2}\left(a^l + a^u + \frac{1}{2}(\beta - \alpha)\right)$$

We have,
Max$\tilde{Z} = 34.83\tilde{x}_1 + 28.42\,\tilde{x}_2 + 8.25\tilde{x}_3 + (0,0,0,0)\tilde{x}_4 + (0,0,0,0)\tilde{x}_5 + (0,0,0,0)\tilde{x}_6$
Subject to:
$15\tilde{x}_1 + 18\tilde{x}_2 + 21\tilde{x}_3 + \tilde{x}_4 + 0\tilde{x}_5 + 0\tilde{x}_6 = (9,63,54,12)$
$16\tilde{x}_1 + 14\tilde{x}_2 + 22\tilde{x}_3 + 0\tilde{x}_4 + \tilde{x}_5 + 0\tilde{x}_6 = (9,61,52,14)$
$7\tilde{x}_1 + 9x_2 + 5\tilde{x}_3 + 0\tilde{x}_4 + 0\tilde{x}_5 + \tilde{x}_6 = (14,35,21,40)$,
$\tilde{x}_1, \tilde{x}_2, \tilde{x}_3, \tilde{x}_4, \tilde{x}_5, \tilde{x}_6 \geq 0$

Initial table

Basis	$\tilde{x}_1$	$\tilde{x}_2$	$\tilde{x}_3$	$\tilde{x}_4$	$\tilde{x}_5$	$\tilde{x}_6$	RHS	$\mathcal{R}(\tilde{\tilde{B}}_i)$
$\tilde{x}_4$	15	18	21	1	0	0	(9,63,54,12)	25.5
$\tilde{x}_5$	16	14	22	0	1	0	(9,61,52,14)	25.5
$\tilde{x}_6$	7	9	5	0	0	1	(14,35,21,40)	29.25
$\tilde{z}$	-34.83	-28.5	-8.25	0	0	0	(0,0,0,0)	

First iteration

Basis	$\tilde{x}_1$	$\tilde{x}_2$	$\tilde{x}_3$	$\tilde{x}_4$	$\tilde{x}_5$	$\tilde{x}_6$	RHS
$\tilde{x}_4$	0	4.88	0.38	1	-0.94	0	$(0.56,5.85,2.25,-1.2)$
$\tilde{x}_1$	1	0.88	1.38	0	0.06	0	(0.56,3.81,3.325,0.88)
$\tilde{x}_6$	0	2.88	-4.63	0	-0.44	1	$(10.06,8.33,-1.75,33.84)$
$\tilde{z}$	0	2.24	39.84	0	2.09	0	(19.51,132.70,111.26,30.67)

Since $\tilde{Z} \geq 0$, the fuzzy optimal solution of the FVLPP is
$\tilde{x}_1 = (0.56,3.81,3.325,0.88)$, $\tilde{x}_2 = (0,0,0,0)$, $\tilde{x}_3 = (0,0,0,0)$ and
$Max\tilde{Z} = (19.51,132.70,111.26,30.67)$.

From the above, it is clear that people want fresh vegetables. It's very hard to get fresh vegetables. And it leads to unhealthy life. In order to subdue from thisproblem, people want Roof Gardening.

Minimize the cost of making roof gardens by using linear programming problem

To minimize the cost of making roof garden by using preliminary data, with respect to varius factors.

Vegetables	**Container**	**Coconut husk (Kg.)**	**Soil (Kg.)**	**Fertilizer (Kg.)**	**Area (Sq.m)**	**Avg. Cost Over the year (Rs.)**
Tomato	5	20	21	7.5	2.5	18
Ladies Finger	7	27	30	9	6.75	25
Radish	11	45	42	10.5	7.25	20
Beans	6	20	22	8	12	25
Brinjal	8	35	36	8	5	20
Requirements	58	212	229	647	3002	

The objective of the function minimize $Z = 18x_1+25x_2+20x_3+25x_4+20x_5$

Subject to constraints $5x_1+7x_2+11x_3+6x_4+9x_5 \leq 58$
$20x_1+27x_2+45x_3+20x_4+35x_5 \geq 212$
$21x_1+30x_2+42x_3+22x_4+36x_5 \geq 212$
$75x_1+9x_2+10.5x_3+8x_4+8x_5 \geq 642$
$2.5x_1+6.75x_2+7.25x_3+12x_4+5x_5 \leq 3002$

where x_1, x_2, x_3, x_4, x_5 are decision variable which represents quantity of Tomato, Ladies Finger, Radish, Beans, Brinjal.

The optimum solution is Z = 113
$x_1 = 0, x_2 = 0, x_3 = 4.26666, x_4 = 0, x_5 = 1.38333$

If we increase the quantity of Radish and Brinjal for 4.27 and 1.39, we can minimize the amount of Rs. 113 for making Roof Garden.

CONCLUSION

Plants with fibrous roots do not cause any harm to the roof but avoid tap roots as they can penetrate the roof and harm it by growing its roots in the structure. Roof garden provides convenience of safe, pesticide free, healthy green and fresh vegetables. It Conducive to a routine of physical exercise, clean air and close to nature. It increases amount of oxygen in air. It reduces overall heat absorption of buildings, Insulates the building against heat and cold. It reduces sound pollution. It acts as a habitat for city weary birds and animals. Plants with fibrous roots do not cause any harm to the roof but avoid tap roots as they can penetrate the roof and harm it by growing its roots in the structure. It reduces indoor temperature by 6- 8 degree and can reduce air conditioning cost by 25% to 50%. Totally roof gardens make our life safe, easy, healthy.

REFERENCES

1. Allahviranloo T., Hosseinzadeh Lotfi F., Kiasary M. Kh., Kiani N.A. and Alizadeh L., Solving fully linear programming problem by the ranking function, 2(2008), 19-32.
2. Bellman R. E. and Zadeh L. A, Decision making in fuzzy environment management science, 17(1970), 141-164.
3. Dhurai K and Karpagam A., Fuzzy optimal solution for fully linear programming problems using hexagonal fuzzy numbers, 5(2016), 533-535.
4. Doshi, R.T., et al. City Farming – the Natural Alternative, Experiences in India. Urban Agriculture Magazine (10) August 20003: 18-19.
5. Ganesan K. and veeramani P., Fuzzy linear programmes with trapezoidal fuzzy numbers, annuals of Operations Research, 143(2006), 305-315.
6. Sahaya Sudha A., Karpagamani V., Solving fully fuzzy linear programming problem using trapezoidal ranking function, 2(2014), 21-26.
7. Tanaka H., Okuda T. and Asai K., On fuzzy mathematical programming, The journal of cybernetics, 3(1974), 37-46.
8. Yagar R.R., A procedure for ordering fuzzy subsets of the unit interval information sciences, 24 (1981), 143-161
9. Zadeh L. A., Fuzzy Sets, Information and control, (1965), 338 - 353.
10. Zimmermann H. J., Fuzzy set theory and its applications, Kluwer Academic Publishers (1985).

Source of support: National Conference on "New Trends in Mathematical Modelling" (NTMM - 2018), Organized by Sri Sarada College for Women, Salem, Tamil Nadu, India.

